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THE MARKET FOR OVERSEAS TELECOMMUNICATIONS IN 1970

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PREPARED FOR:
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The RAND Corporation
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PREFACE

This RAND Memorandum is a product of the study of the economic implications of communications satellites conducted by The RAND Corporation for the National Aeronautics and Space Administration under contract No. NASr-21(01). Other recent RAND Memoranda prepared under this contract are: R. T. Nichols, High-Capacity Submarine Telephone Cables: Implications for Communication Satellite Research and Development, The RAND Corporation, RM-3877-NASA, September 1963; R. L. Slighton, Overseas Telecommunications Traffic and Commodity Trade, The RAND Corporation, RM-3817-NASA, September 1963; and Jora R. Minasian, Telephone Rates, Queues, Costs: Some Economic Implications for Analyzing Fluctuating Demands, The RAND Corporation, RM-3829-NASA, September 1963.

This Memorandum investigates the question of the size and configuration of the market for overseas telecommunications services in the year 1970. It is designed to provide background information of use to officials of the National Aeronautics and Space Administration and other government agencies responsible for communications satellite research and development policy.

Knowledge of the size of the market for telecommunications services over the next ten years is of importance to any major decision with respect to system design or pace of development in the field of communications satellites. The importance of this problem (as well as its intractability) suggests that the basis upon which such estimates are established should be stated clearly. The most publicized forecast of future overseas telecommunications capacity requirements has been that made by the Ad Hoc Committee of Common Carriers, which reported to the Federal Communications Commission in 1961. The rationale of their forecast was not given. Preliminary investigation suggested that these estimates were somewhat misleading, thus a research project that was originally confined to the prospects for the development of the market for new uses of overseas telecommunications facilities was expanded into a study of the market as a whole.

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SUMMARY

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According to the analysis presented here, it is estimated that the demand for telecommunications between the United States and overseas points in 1970 will create a capacity requirement of 1700-2250 voice trunks for telephone service and 300-400 voice channels for leased line and record services. The latter estimate includes government requirements for broadband circuits. The demand for telecommunications on overseas routes not involving the United States will create an additional requirement of 500-650 voice trunks for telephone service and 100-150 voice channels for record services. All estimates are based on the following assumptions: quality of service is excellent (very short waiting times and signal quality comparable to service over domestic circuits); virtually all overseas routes that are now provided with direct telegraph circuits will be provided with direct telephone circuits in 1970; the relative price of telecommunications services will continue to decline at the rate of 1-2 per cent per year.

The estimate given above of total capacity requirement for routes involving the United States is 55-70 per cent of the estimate of the 1961 Ad Hoc Carrier Committee. Given the rates of increase forecast in this Memorandum, the committee's forecast of total requirements is appropriate for 1972 or 1973 rather than 1970. However, comparison of total requirements does not reveal the main difference between the two forecasts. The differences between the estimates of the requirements for the bulk routes to Europe, Hawaii, and Puerto Rico are much smaller than the differences for the routes to South America, Africa, and Asia. For the latter routes, the estimates given in this Memorandum are 25-40 per cent of the committee's estimate.

Most of the capacity requirement on overseas routes in 1970 will derive from the demand for telephone service. Increasing use of electronic data-processing equipment will lead to a substantial growth in the demand for high-speed data transmission, but these requirements will be met largely through the use of circuits of bandwidth no greater than one voice channel. Almost all the demand for transmission of information at rates that cannot be achieved over one voice channel

will come from the government. Given the likely costs of providing bandwidth on overseas routes in 1970, the effective demand for overseas transmission of television will probably be limited to transmission during off-peak hours over those routes where the peak demand for telephone service creates a bandwidth requirement that is approximately as large as the requirement for real-time transmission of television. Cost considerations are likely to rule out a demand for bandwidth to provide for facsimile transmission of overseas mail or overseas transmission of television on a closed-circuit basis for purposes other than entertainment.

A substantial portion of 1970 capacity requirements for overseas telecommunications will be supplied by submarine cable systems. For comparison of the demand and supply of telecommunications capacity it is convenient to distinguish between routes where submarine telephone cables are now or soon will be in service and routes that will not be served by cable. If cable construction is limited to those systems scheduled for completion by 1965, the capacity required on noncable routes in 1970 will be about half the new capacity required to accommodate the 1970 demand on cable routes. If cable construction over the bulk routes to Europe, Hawaii, and Puerto Rico is not limited to that set of cables scheduled for completion through 1965, the new capacity required by 1970 will be virtually limited to the noncable routes. The number of circuits required over any one of these noncable routes is not large. Therefore, a communication satellite system designed to meet the needs of 1970 is likely to need substantial multiple access capabilities. It is important that analyses of tradeoff between costs of orbital systems and ground stations reflect this possibility.

Author

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I. INTRODUCTION AND GENERAL CONCLUSIONS

The efficiency of space communications systems relative to each other and to conventional means of long-distance communication is a function of the volume of telecommunications that they are likely to have to accommodate. Revenue and cost estimates are both dependent upon knowledge of the size of the market, yet there has been little detailed analysis of the probable size and configuration of the future market for overseas telecommunications, particularly with respect to those broadband services that may be available only when satellite systems are in operation.* To the extent that the future size of the market has been considered in analyses of communications satellite systems, the estimates of the Ad Hoc Carrier Committee have tended to dominate discussion. Despite the advantages that the carriers can be presumed to have with respect to market forecasting, this set of estimates seems very questionable. In any event, it is desirable that the assumptions imbedded in these estimates be brought to light and the implications of alternative assumptions be explored.

The general conclusions of this Memorandum are stated in this section. Section II is a methodological discussion of some of the problems that are encountered in attempting to forecast the future demand for overseas telecommunications. An attempt is made to explain why a "naive" method of forecasting was adopted in this study -- extrapolation of the variable to be predicted according to rates obtained from analysis of past changes in that variable -- instead of an explicit model of behavior that explains the dependent variable in terms of causal relationships of known quantitative significance. Section III is a discussion of the changes in the market for overseas telecommunications during the period 1950-1962. The traffic experience of these years is examined in order to estimate the effect of changes in quality of service on demand and to establish trends in the rate

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*For reference to previous discussions of the future size of the market for overseas telecommunications, see Appendix A.

of increase of demand. The assumptions made to arrive at the forecast of the demand for conventional telecommunication services in 1970 are presented in Section IV. Section V is a discussion of the special problem of estimating the demand for broadband channels. The analysis is restricted to three of the most commonly mentioned markets for broadband services: government and commercial demand for broadband channels for alternate voice and data transmission; facsimile transmission of overseas mail; and television transmission.

There are three major conclusions reached in this Memorandum. First, the aggregate demand for telecommunications between the continental United States and overseas points in 1970 is likely to require 1700-2250 voice trunks for provision of telephone service and 300-400 voice channels for leased line and record services. The latter figures include an estimate of government demand for broadband channels. The demand for overseas telecommunications over routes not involving the United States is likely to impose an additional requirement of 500-650 voice trunks for telephone service and 100-150 voice channels for record services. Second, the great bulk of the requirements for telecommunications services in 1970 will derive from the demand for message telephone service. If a "broadband channel" is defined as a circuit with more information capacity than one voice-grade channel, there will be only negligible demand from the private sector of the economy for broadband channels between the United States and overseas points. The effective demand for overseas television transmission in 1970 will probably be limited to spot-leasing of a television channel during off-peak hours over routes where the bandwidth required for telephone service during peak hours approaches the bandwidth requirement for real-time transmission of television. Third, at least 30-35 per cent of the sum of the differences between capacity requirements and the available capacity of submarine telephone cables over all routes is accounted for by the requirements of routes that have relatively modest capacity requirements on an individual route basis. If cable construction continues after 1965, this percentage will be higher. Most of the difference between the forecast of total capacity requirements and

the capacity of the submarine cable network at that date would derive from the requirements of those routes that are not served by submarine cable facilities if high capacity submarine cables were constructed between the United States and Europe and between California and Hawaii before 1970.

The distribution by route of the estimated capacity requirements for various telecommunications services is given in Table 1. The transatlantic route will continue to be the most important individual route. If the traffic estimates for telephone service between Europe and all points in North America are considered as a total, approximately 50 per cent of all overseas telephone traffic is expected to occur over the transatlantic route. About 40-45 per cent of the aggregate capacity requirements for leased line and record services are accounted for by transatlantic demand.

The estimate of the total overseas telecommunications requirement for the United States given in Table 1 is considerably less than the estimate given by the Ad Hoc Carrier Committee. For the same geographical coverage the committee forecast a requirement of some 3800 voice channels for all overseas telecommunications services other than television transmission.* This total was apparently derived by summing trunk requirements for telephone service and channel requirements for other services, so the corresponding total as estimated in this Memorandum is about 2000-2700 circuits, or about 55-70 per cent of the committee's estimate. Taken as an aggregate, the difference between the estimates amounts to about two or three years of traffic growth. That is, an estimate of the capacity requirement for 1972 or 1973 based on the assumptions adopted in this Memorandum would be about the same as the estimated requirement for 1970 as given by the committee. However, this does not give a true picture of the differences between the two sets of estimates. The bulk route estimates given in this Memorandum are much closer to the estimates of the committee than are the estimates of capacity requirements for routes with relatively

*For a geographical breakdown of the estimates of the Ad Hoc Carrier Committee, see Appendix B.

Table 1

OVERSEAS TELECOMMUNICATIONS CAPACITY REQUIRED FOR ACCOMMODATION OF DEMAND FOR CONVENTIONAL SERVICES IN 1970

Link	Message Telephone (trunks)	Record Transmission (channels)	U.S. Government Demand (channels)
U.S. - Europe	700-950	60-80	64-96
U.S. - Hawaii	325-390	15-20	16-32
U.S. - East Asia	65-108	17-23	48-64
U.S. - Oceania	23-30	4-5	-
U.S. - South America (including Panama)	100-155	15-25	16
U.S. - Central America	30-50	3-4	-
U.S. - Caribbean Islands[a]	400-500	20-25	16
U.S. - Rest of World	35-55	7-11	-
Total U.S. Requirements	1700-2250 (approx.)	150-200 (approx.)	160-224
Rest of World - Rest of World	500-650	100-150	n/a
Total World Requirements	2200-2850 (approx.)	250-350 (approx.)	160-224

Note:

[a]Excluding requirements between the United States and Cuba, Bermuda, and the Bahamas.

modest requirements. The estimate of the capacity requirement for traffic between the United States and Asia plus Africa given in Table 1 is approximately 30-50 per cent of the relevant estimate of the Ad Hoc Carrier Committee. The coresponding figure for traffic to Latin America is about 30-40 per cent. At the rates of growth predicted in this Memorandum, these differences amount to about ten years' growth.

The conclusion that the private sector's effective demand for broadband channels is likely to be negligible depends jointly on (1) a conclusion as to the overseas communication requirements of large firms, (2) a prediction that terminal equipment will be introduced that will permit an increased rate of transmission of information over a channel of given bandwidth, and (3) consideration of the probable costs of such services. The seeming difference between this conclusion and the estimates of various industry spokesmen is partly the result of differing definitions. In the terminology of the industry, a "broadband" channel may be a channel derived from the bandwidth of less than one voice channel. Such a channel is "broadband" only in reference to a 60 word-per-minute telegraph channel. There appears to be no demand from the private sector for channels with an information capacity of anything like the 40.8 kilobit-per-second capacity of the channels the government may wish to lease.

The demand for television transmission is quite problematical. It is uncertain what the public response to direct transmission of overseas television programs will be. The response of the networks and the sponsors of network programming to the possibilities of direct transmission of overseas television is also uncertain. Less questionable is the prediction that the cost of a full time lease of an overseas television channel will be very large relative to the costs of domestic transmission. Since storage on videotape for rebroadcast during prime viewing time is already a commonly employed network programming practice, the maximum effective demand for overseas television transmission in 1970 seems likely to be limited to off-peak transmission over routes where the capacity required for conventional

telecommunications services during peak periods is of a similar order of magnitude to the capacity requirement for real-time transmission of television.

There are a number of difficulties encountered in any attempt to compare the estimates of required capacity given in Table 1 with the capacity available over submarine cable systems in 1970. First, the plans for cable construction by the American Telegraph and Telephone Company and foreign telecommunications authorities are quite uncertain after 1965.* Second, for relatively large amounts of bandwidth (equivalent to 24 or more voice channels), more telephone trunks can be obtained from that bandwidth than voice channels. This difference arises from the application of time assignment speech interpolation (TASI) techniques. Application of TASI techniques nearly doubles the number of telephone conversations that can be carried over a given amount of bandwidth. However, for purposes of converting the estimates of Table 1 into estimates of required bandwidth (in terms of the number of voice channels) there is a problem of discreteness. TASI techniques are applied to discrete amounts of bandwidth with the result that the ratio of the number of voice channels used to obtain a given number of voice trunks to that number of voice trunks is somewhat variable. The capacity requirements given in Table 2 were obtained by adopting the convention that this ratio is .55. That is, where 50 or more voice trunks are required for the demand for telephone service between two points, the ratio of the required number of voice channels to the required number of voice trunks is .55. This convention is not meant to be a prediction. The suppliers of telecommunications services may choose to limit the application of TASI in the future. The capacity requirements in Table 2 are simply approximations of the minimum bandwidth (in terms of voice channels) that would be required in 1970 to accommodate demand as estimated in Table 1. The fact that the ratio of the required number of circuits (telephone trunks plus channels for other services) given in Table 1 to the required number of channels

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*For a discussion of the planned capacity of submarine cable systems, see Appendix C.

Table 2

THE DIFFERENCE BETWEEN CAPACITY REQUIREMENTS IN 1970 AND THE AVAILABLE CAPACITY OF SUBMARINE CABLE SYSTEMS
(voice channels)

Link	Capacity Requirements[a]	Capacity Requirements Not Fulfilled by Cable Systems
U.S.-Europe	510-700	none,[b] 35-225,[c] 165-355[d]
U.S.-Hawaii (including transit traffic)	340-435	none,[e] 0-130,[f] 155-260[g]
U.S.-East Asia	105-148	0-20
U.S.-Australia and New Zealand	27-35	none
U.S.-Caribbean Islands (including transit traffic)	330-430	65-130[h]
U.S.-Central America, Colombia, and Venezuela	120-180	none
U.S.-Rest of South America	45-70	45-70
U.S.-Rest of World	42-66	42-66
Rest-of World-Rest of World	500-700	400-600[j]

Notes:

[a]For relationship between estimates of capacity requirements in terms of voice channels and requirements stated in Table 1 see text (pp. 6-8).

[b]Presumes construction of TAT-5 as a 720 voice channel cable.

[c]Presumes construction of TAT-5 as a 128 voice channel cable.

[d]Presumes no cable construction subsequent to TAT-4.

[e]Presumes construction of a 720 voice channel cable.

[f]Presumes construction of a third cable to Hawaii -- second generation type of cable (128 voice channels).

[g]Presumes no cable construction to Hawaii other than that currently announced.

[h]Presumes construction of a third cable to Puerto Rico -- second generation type of cable.

[j]Presumes no additional cable construction between Canada and Europe.

given in Table 2 differs between the various routes is a reflection of differences in the absolute volume of traffic and in the relative importance of telephone service and other services. TASI techniques are not practicable over routes where the demand for telephone service can be accommodated over a small number of trunks.

According to Table 2, if only those cables are constructed whose construction plans have been announced, the sum of the differences between required capacity and the available capacity of cable systems over all overseas routes will be about 900-1500 voice channels. For routes involving the United States this total is 500-900 voice channels, about 80 per cent of which derives from the bulk routes to Europe, Hawaii, and Puerto Rico. For the world as a whole, 30-35 per cent of the sum of the differences between required capacity and available cable capacity derives from the requirements of routes over which there will be no cable service.

The capacity required to accommodate the demand for telecommunications service between the United States and Europe and between the continental United States and Hawaii would exceed the capacity of the submarine cable network over these routes by 1967 or 1968 if cable construction were to cease with those projects that have been announced. If the choice is made to augment the capacity over these routes before 1970 by construction of high-capacity submarine cables (720 voice channels),* almost all the difference between capacity requirements and the available capacity of submarine cable systems over routes involving the United States would be the requirements over those routes that will not be served by cable facilities in 1965. This statement would apply to total world traffic if the capacity of the transatlantic portion of the Commonwealth cable system were sufficiently augmented.

Unless submarine cable construction ceases after 1965 (or unless the demand for broadband channels develops much more rapidly than is foreseen in this Memorandum) the commercial future of communications

*See R. T. Nichols, High-Capacity Submarine Telephone Cables: Implications for Communication Satellite Research and Development, The RAND Corporation, RM-3877-NASA, September 1963.

satellites over the next ten years appears to be closely bound to the possibility that satellite systems can compete successfully with high-frequency (HF) radiotelephone systems over routes of relatively low traffic density. Investigations into the question of an optimal tradeoff between the costs of the orbital system and the costs of the ground stations should reflect this possibility. For example, if the problem of achieving multiple access capabilities is less troublesome and the costs of providing ground stations are less for satellites in synchronous orbit than for satellites in random orbit at medium altitudes, then the relative advantages of a synchronous altitude system may be of greater importance and its relative disadvantages of lesser importance than has been previously thought.

II. BASIC PROBLEMS OF FORECASTING

The previous section was introduced with a statement as to the importance of forecasts of the size of the overseas telecommunications market to systems analysis of communication satellites. It is, of course, much easier to make a case for the need to forecast than it is to make a case for a particular forecast. This is particularly true of the market for overseas telecommunications, where the barriers to meaningful market projections are formidable. It may be convenient to consider these forecasting problems in two groups: the first set of barriers relates to estimation under circumstances in which past demand figures are known, and the second set of difficulties relates to the problems of using historical traffic figures as estimates of past demand.

Even if it is assumed that traffic figures are a good index of telecommunications demand, it is difficult to arrive at an explanation that can serve as the basis for market forecasts. The list of factors that are likely to be of some importance in determining the volume of telecommunications demand is quite long, and the relative importance of the various factors over different overseas routes is quite different. Many of the important determinants of telecommunications demand, such as the degree of commonality of language, cannot be measured directly. Information about many of the measurable determinants of demand such as tourism and gross capital flows is too incomplete to permit quantitative analysis. If there were no limitations on the availability of data and if a way were found to take into account the nonquantifiable determinants of demand such that an explanatory model of reasonable completeness could be constructed, the problem of the limited number of observations would remain. The underlying conditions of supply and demand for overseas telecommunications prior to the Korean War were sufficiently different from these same conditions today that it does not seem advisable to test market hypotheses on data prior to 1949 or 1950.

The various limitations on the availability of data preclude the construction of formal explanatory models that are likely to take into account enough of the determinants of telecommunications demand to be useful. Demand is sensitive to a great variety of factors. Formal explanatory models that treat the demand for overseas telecommunications services as a function of one or two variables are not likely to explain this demand satisfactorily. For example, only a small proportion of changes in telecommunications traffic since 1950 can be "explained" in terms of changes of trade.* The American Telephone and Telegraph Company has attempted to predict the future volume of overseas telecommunications demand on the basis of the growth of the number of telephones. However, although the rate of growth of the number of telephones in various parts of the world may be predicted with some confidence, the future propensity of the average telephone subscriber to use his telephone for overseas service is very difficult to forecast. The AT&T model sweeps the basic uncertainties of future market changes under the rug.

The volume of overseas telecommunications traffic does not provide a very good index of the quantity of telecommunications services demanded. The volume of services traded in a given market is a function of supply as well as demand, and one of the most difficult problems in forecasting demand for telecommunications is the determination of the extent to which the volume of overseas telecommunications traffic in the past has been influenced by considerations of supply. The demand for message telephone service is not a simple function of price, since demand is largely time specific. The basic equilibrium mechanism today is a quality degradation process where the most important determinant of quality is the difference between the time when the service is made available and the time when it is wanted. The number of messages that would be demanded of a system having a capacity that permitted a traffic density of 20 messages per circuit per day

*R. L. Slighton, Overseas Telecommunications Traffic and Commodity Trade, The RAND Corporation, RM-3817-NASA, September 1963.

is quite different from the number of messages demanded of a system requiring a traffic density of 40 messages per circuit per day.

It is of particular importance that the relationship between the quantity of telecommunications services demanded and the quality of those services be considered when past traffic figures are analyzed with an eye towards estimation of long-term "normal" rates of increase of demand. The number of telephone messages between the United States and Europe increased at the average yearly rate* of 6.8 per cent in the period 1950-1955. The corresponding rate for the period 1955-1960 was 22.0 per cent. A more accurate picture of changes in traffic volume is given by comparison of the rates of growth of revenue from message telephone service. On this basis the difference in traffic growth between these two periods is even greater. Revenue derived by AT&T from the North Atlantic link increased at the average yearly rate of 6.1 per cent during 1950-1955 and 27.1 per cent between 1955 and 1960. It is no accident that the higher rates of growth of traffic are found for the later period, since the period 1955-1960 spans the construction of the transatlantic cables, TAT-1 and TAT-2, and the augmenting of the message capacity of these cables by bandwidth reduction and TASI techniques. Differences in the rate of growth of trade and tourism are a partial explanation of the higher rate of growth of transatlantic telephone traffic since 1955, but the basic explanation seems to be in terms of changes in the conditions of supply. For most transatlantic links the introduction of cable service has meant a substantial reduction of queueing time as well as an improvement in the quality of the signal received. The problem of analysis is thus distinguishing between increases in traffic that would have occurred in the absence of a change in quality of service and increases in traffic that are a response to quality change.

Quality is also a function of the physical properties of the circuit provided, and the switch to cable circuits over certain links

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*By the term "average" yearly rate of increase is meant the geometric mean of the year-to-year rates of increase during the period in question.

during the period 1956-1960 presents a second major problem in using traffic data of the base period to forecast demand in the future. Since the circuits derived from telephone cables provide a better connection than do high-frequency radio circuits, some of the traffic changes during the base period reflect consumer response to changes in this aspect of circuit quality. This is a once-and-for-all effect, and it is desirable to eliminate this response from any estimate of the "normal" long-term growth rates. The increases in demand that were a response to improvement in the quality of connection occurred more or less coincidentally with the traffic increases that were a response to reduction of waiting time. Therefore, it is exceedingly hazardous to estimate their magnitude.

An additional problem in using available traffic data as a basis for projection of demand is that the datum most commonly available is the number of messages. Of more interest, however, is the number of revenue minutes, the product of the number of messages and the average length of the message. Data on length of message are not available on a systematic basis, at least outside the telephone industry. Revenue and message data taken together are sufficient to calculate changes in message length if prices are constant, but revenue data are regularly available only for aggregates. In addition, the changes in circuit quality attendant upon the shift from radio to cable have in some instances been coincident with a change in the price structure. This complicates the calculation of message length.

The problems discussed above relate to the demand for message telephone service. The overseas demands for telex, datatelex, facsimile transmission, and television are even less amenable to analysis and prediction. For example, intercontinental telex traffic is still in the phase of super-rapid growth characteristic of new services, and datatelex service was inaugurated only within the last year.

The discussion of the problems of forecasting the overseas telecommunications market has been presented to give some background to the decision to make forecasts directly on the basis of extrapolation

of past trends in the volume of telecommunications. The construction of formal models would be pretentious. Data on the determinants of demand are too limited and the relationship between traffic volume and the quantity of service demanded is too obscured by supply considerations to permit a thorough explanation of the past in terms of formal behavioral models. And if demand in the past could be explained in terms of a set of variables such as trade, tourism, capital flows, and the number of telephones, the problem of predicting these explanatory variables would remain. Unless the future rate of growth of these variables is thought to be different from their rate of growth in the past, they will be predicted by extrapolation according to their own past rates of growth. The forecast of the volume of overseas telecommunications services provided by a formal model, whose predictive variables must be themselves predicted by extrapolation of past trends, will be much the same as the forecast extrapolated from past trends of the variable to be predicted.

III. ANALYSIS OF THE GROWTH OF OVERSEAS TELECOMMUNICATIONS IN THE PERIOD 1950-1962

THE GROWTH OF TELEPHONE TRAFFIC

Traffic Involving the United States

As can be seen from Table 3, the growth of overseas message telephone traffic in the recent past has been quite uneven, both by year and by area. For the period 1950-1962, total overseas telephone traffic showed a 14.8 per cent average annual rate of increase* when measured by number of messages and a 16.1 per cent average annual rate of increase of revenue, the difference arising from changes in the proportions of messages made at various prices, and increase in average length of message, and some change in price (on calls to Hawaii and Puerto Rico). This rate of change has not been characteristic of the entire time period, however. For the pre-cable years 1950-1955, messages increased at the average annual rate of only 10.8 per cent and revenue increased 10.3 per cent on the average. These averages are strongly affected by the tremendous jump in messages and revenue to the Far East in 1950-1951 because of the Korean conflict.

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*"Average" rate of increase means the geometric mean of the year-to-year rates of increase during the period in question. This rate can be calculated easily through the relationship $\log(1 + r) = (1/n) \log(Y_n/Y_o)$, where Y_n is the volume of traffic in the last year of the period, Y_o is the volume of traffic in the first year, and "r" is the average rate of increase. A method of describing the growth of traffic over a particular time period that uses more of the available information is the estimate of the time trend which is obtained through regression analysis. This rate is that rate "r" which minimizes the sum of the squared deviations of the logarithms of the observed values of traffic from the estimates of the logarithm of traffic obtained from the regression model $\log Y_t = \log A + t \log(1 + r)$. The latter rate, called here the "trend," is obtained with more computational effort than the so-called "average" rate of growth. Where descriptive statistics are needed for purposes of rough comparisons only, the measure requiring less computation will be employed. Where a statistic that may be used for extrapolation is required, the rate obtained through regression analysis will be used. In general, the two statistics are quite similar in magnitude for the data in this study.

Table 3

THE NUMBER OF TELEPHONE MESSAGES BETWEEN THE CONTINENTAL UNITED STATES AND OVERSEAS AREAS, 1950-1962
(millions of messages)

Area	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
Europe	.281	.304	.286	.309	.328	.391	.484	.648	.718	.832	1.058	1.207	1.463
South America	.118	.134	.140	.142	.148	.162	.180	.194	.202	.215	.221	.230	.254
Puerto Rico	.041	.052	.057	.072	.086	.106	.125	.147	.175	.200	.344	.466	.615
East Asia	.084	.171	.201	.208	.193	.162	.170	.167	.154	.157	.154	.156	.171
Australia and New Zealand	.009	.011	.009	.009	.011	.014	.015	.014	.017	.020	.024	.026	.033
Hawaii	.091	.114	.132	.138	.150	.178	.205	.241	.350	.430	.515	.565	.697
Total Overseas (excluding Cuba and the Bahamas)	.682	.857	.903	.972	1.030	1.137	1.320	1.572	1.798	2.056	2.539	2.914	3.587

Source:

Federal Communications Commission, Statistics of Communications Common Carriers, 1950 through 1961 (Washington, D.C., Government Printing Office) for data for the years 1952-1961 and unpublished records of the Common Carrier Division of the Federal Communications Commission for data from the years 1950, 1951, and 1962.

If 1951-1955 is chosen as the pre-cable reference period, the average yearly increases in messages and revenue are only 7.3 per cent and 7.2 per cent respectively.

Since 1955 there has been a noticeable quickening of the pace of growth of overseas message telephone traffic. Overseas messages increased 17.8 per cent per year on the average and message revenue increased at an average yearly rate of 23.9 per cent during the period 1955-1962. The marked difference in the rates of growth of messages handled by AT&T and AT&T message revenue derives largely from a noticeable increase in length of message for all areas in which cables have replaced high-frequency radio facilities.

The differences in rates of increase of message volume are also noticeable when traffic to different areas is compared. During the period 1955-1962, message volume to Western Europe increased at the average yearly rate of 20.7 per cent and message revenue increased at the rate of 25.2 per cent. During the same period message traffic to South America increased at the rate of only 6.6 per cent. Traffic to the Far East exhibited virtually no growth during the period 1955-1962, while traffic to Hawaii increased at the average yearly rate of 21.5 per cent and traffic to Australia and New Zealand increased at the rate of 13.4 per cent. The increase in the volume of messages to Hawaii considerably understates the increase in revenue minutes. Message length increased about 35 per cent during the period 1956-1959 alone, but some part of this increase derived from a one-fifth reduction in the price of extensions to the basic three-minute period. Message volume to Puerto Rico increased at the average yearly rate of 28.5 per cent during 1955-1962.

For the earlier period, 1950-1955, the differences in growth rates for traffic to different areas are somewhat less pronounced. During this period, message volume to Western Europe increased at the average yearly rate of 6.8 per cent, message revenue increasing about at the rate of 5.2 per cent, the average length of message having fallen somewhat. Other average yearly rates of increase during the

period 1950-1955 were as follows: 8.4 per cent to Australia and New Zealand; 14.4 per cent to Hawaii; 20.6 per cent to Puerto Rico; 6.5 per cent to South America; and 14.0 per cent to the Far East.*

Since the year-to-year variation in the rate of change of telephone traffic is fairly sensitive to changes in the volume of overseas trade, it is important that estimates of the long-run "normal" rate of increase or "trend" of telephone traffic be obtained for time periods that begin and end in the same phase of the trade cycle. There are two long periods within the span of years being investigated that meet this criterion reasonably well. The period 1953-1961 extends from the trough of the post-Korean War overseas trade recession to the latest trough year. The period 1951-1962 extends from the peak of the Korean War trade boom to a year of substantial trade expansion. The trends in the rate of growth of telephone traffic as estimated by linear regression of the logarithms of telephone traffic against time for these two periods are given in Table 4. These rates by themselves do not provide a satisfactory basis for prediction of the future. For those routes over which submarine cable facilities have replaced HF radiotelephone channels, the trends given in Table 4 exhibit an upward bias because of increases in the quality of service over the entire period. In addition, the differences between the peak-to-peak and trough-to-trough trends calculated for traffic to Europe and Hawaii are exaggerated somewhat because of the concentration of improvements in quality of service in the subperiod 1957-1961.

The introduction of overseas cables seems to have had two separate effects. First, the great increase in number of circuits reduced queueing time substantially (as much as 60 minutes on some circuits) and increased the number of messages that could be handled

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*The rate of 14.0 per cent to the Far East is not particularly meaningful. Traffic approximately doubled from 1950 to 1951 and continued to increase somewhat until 1953, when message volume was 2-1/2 times that in 1950. Subsequently, traffic declined more or less continuously through 1958.

Table 4

TRENDS IN THE YEAR-TO-YEAR RATE OF INCREASE OF THE NUMBER OF TELEPHONE MESSAGES FOR VARIOUS OVERSEAS ROUTES
(per cent)

Route	Peak-to-Peak[a] (1951-1962)	Trough-to-Trough (1953-1961)
U.S.-Europe	17.3	19.8
U.S.-South America (including Panama)	6.2	6.7
U.S.-Puerto Rico	24.6	24.7
U.S.-Australia and New Zealand	11.6	12.8
U.S.-Hawaii	19.0	21.4

Note:

[a]The period 1950-1959 comes closer to being a peak-to-peak trade period for the route U.S.-South America than does the period 1951-1962. Accordingly, the peak-to-peak trend in traffic over that route was calculated from the data for the years 1950 through 1959.

Source:

See Table 3.

during hours of convenience. Although difficult to estimate, the traffic increase induced by the provision of greater capacity typically seems to have been on the order of 25-50 per cent of the traffic carried on the previously existing facilities. Second, the switch from HF radiotelephone to cable circuits resulted in a sufficient improvement in signal quality on overseas calls to warrant the assertion that a cable message is a substantially different good. Message length has typically increased 20 per cent following introduction of cable service. In addition, the improvement in signal quality induced an increase in the number of messages demanded. Although it is analytically possible to distinguish between increases in demand that are a response to reduction of waiting time and increases in demand that are a response to improvement of signal quality, their relative importance cannot be estimated. Considering the 25-50 per cent increase in the number of messages and the 20 per cent increase in message length resulting from the decrease in queueing time and improvement of the physical quality of the circuits together with the "normal" yearly increase of the number of messages of 15-20 per cent, a change from HF radiotelephone circuits to circuits of cable quality is likely to be followed by an increase in telephone traffic of between 70 per cent and 120 per cent within a year of the opening of cable service. The extent of the increase will depend on the degree of overcrowding on the radiotelephone circuits, the physical properties of the previously existing HF circuits, and the "normal" rate of increase for the link concerned.

Some specific examples of the effect of the substitution of cable circuits for HF circuits on traffic and revenue are as follows. Message volume from the United States to the United Kingdom increased by about 65 per cent from 1956 to 1957. This increase understates the impact of cable installation on telephone traffic because TAT-1 was in operation during the last three months of 1956. The increase in revenue during this same period was about 100 per cent. The number of messages to Hawaii in 1958 was about 45 per cent greater than the corresponding figure for 1957 although the Hawaiian cable

was in operation during the last few months of 1957. In the year following the installation of cable service to Puerto Rico in January of 1960, the number of messages increased about 70 per cent. Message volume to Germany, France, and Italy increased about 43 per cent during the first full calendar year following completion of TAT-2.

The rates of growth of telephone messages during 1950-1962 do not relate to service of constant quality nor to service of a quality approaching that of U.S. domestic service. The differences in circuit crowding between overseas and domestic routes preclude measurement by the same standards, domestic service being rated on a probabilistic basis (the chance of not placing a call immediately) and overseas service on the basis of average waiting time. Average waiting time on calls to Europe was about 15 minutes during 1962, although this varied widely between countries and by time of year -- from 113 minutes on calls to Spain in March to 6 minutes on calls to Germany in September and November. The average of monthly figures on waiting time in 1962 was 8.0 minutes on calls to Germany, 15.6 minutes on calls to the United Kingdom, and 10.7 minutes on calls to France. The more crowded circuits averaged around 30 minutes waiting time. The differences in waiting times between countries reflect the presence or absence of cable service and differences in the amount of investment in the transatlantic cables (and hence the number of available circuits) between the various European telecommunications authorities. Over the period 1950-1962 there was a general reduction in waiting time on routes to Europe, Hawaii, and the Caribbean. Waiting times do not seem to have changed very much for most of the links provided by HF radio. Waiting time to South American points has been fairly stable and has even worsened to some points apparently because of the overloading of local circuits. Average waiting time in 1962 on calls to Argentina and Brazil was about 28 and 23 minutes respectively.

The waiting time variable is useful as an index of the potential traffic that would be forthcoming if load factors on overseas circuits could be reduced and as a basis for estimating the extent to

which recent traffic growth figures reflect consumer response to improvement in quality of service. Where the channel capacity of a given link and the time pattern of demand for messages over that link are such that peak demand cannot be accommodated without time delay, it is inevitable that some potential traffic is lost. The traffic loss is a function of the extent to which capacity constraints require a shift of the unconstrained time pattern of demand, or the difference between the time pattern of traffic and the time pattern of demand. Average waiting time is a rough index of this difference, although this statistic is a somewhat imperfect measure of potential traffic loss since the difference between waiting time for calls made during peak periods and average waiting time for all calls is likely to be quite different for various links.

The nature of the relationship between the magnitude of the reduction of average waiting time and the proportionate increase in the number of telephone messages demanded is uncertain. The reduction in traffic associated with capacity constraints may be more than proportional to the increase in waiting time since some customers will not switch to an alternative means of communication unless the waiting time exceeds a certain critical range. There is some justification to this a priori line of argument but there is a counter tendency, the prevalence of impulse calling. Even short delays may result in cancellation of message plans in such cases, and AT&T seems to feel that impulse calls are by no means a trivial proportion of total demand. As a result of these two conflicting tendencies the effect of capacity restraints on overseas traffic may be more or less proportional to average waiting time.

Traffic Not Involving the United States

The data on traffic involving the United States are more reliable than any other. The most complete summary of world overseas telephone traffic is that made for the year 1960 by H. M. Flinn. These estimates were released from the files of the American Telegraph and Telephone Company. According to these estimates, the volume of

overseas traffic involving the United States was about 71 per cent of the total world overseas traffic in 1960 if the totals are defined so as to exclude traffic between Europe and North Africa and traffic between the United States and Cuba (and the Bahamas). Excluding traffic between the United States and the rest of the Caribbean area reduces U.S. participation to some 67 per cent of world traffic, and exclusion of Hawaiian traffic reduces this ratio to 60 per cent. The participation of other areas in world traffic can be estimated from the first three columns of Table 5. The proportions of total world overseas telephone traffic carried over particular routes according to Flinn's estimates are reported in the first three columns of Table 6. These figures all apply to the year 1960.

Certain of the estimates in Flinn's study appear questionable, however. The counts of traffic involving South Africa and South Asia are not consistent with the estimates of telephone traffic originating in the Commonwealth countries for the period March 1960-March 1961 reported by the British Post Office. Since the estimate of South African traffic was apparently used as a benchmark to establish a total for the rest of Africa, the latter figure may also be over-estimated. There is also a question as to the inclusiveness of Flinn's estimates with respect to the definition of what should be considered an overseas or intercontinental route. For example, Flinn's totals include traffic between Japan and Korea or Okinawa and traffic between Central America and the countries of South America that border on the Caribbean. The feasibility of providing communication by microwave or troposcatter radio techniques over short routes suggests that such traffic might well be excluded from a count of overseas or intercontinental traffic if the purpose of the count is the study of the potential market for satellite communications. If the estimates of Flinn's study are adjusted to reflect the possibility of either an overcount or inappropriate coverage, 69 per cent of total overseas telephone traffic involves the

Table 5

THE DISTRIBUTION BY AREA OF WORLD OVERSEAS TELEPHONE TRAFFIC[a]
(per cent)

Area	Definition I[b]	Definition II[c]	Definition III[d]	Definition IV[e]
North America (including Caribbean area)	50.1	38.0	35.5	39.4
United States	(35.4)	(33.3)	(29.9)	(34.3)
Europe	21.7	27.0	33.0	34.6
South America	4.3	5.3	6.4	6.3
Africa	3.1	3.9	4.7	2.7
Middle East and South Asia	4.0	4.9	6.2	4.4
Japan	2.9	3.5	4.4	3.6
East Asia other than Japan	3.4	4.3	5.3	4.5
Australia and New Zealand	3.1	3.9	4.5	4.5
Hawaii	7.4	9.2	-	-
Total	100.0	100.0	100.0	100.0

Notes:

[a]"Shares" of traffic were computed by determining the ratio of messages involving the area in question to total world volume and then dividing by two. The latter adjustment accounts for the fact that a single call has two termini.

[b]Definition I defines world traffic as embracing all overseas messages except traffic between France and Algeria and traffic between the United States and Cuba, the Bahamas, and Alaska.

[c]Definition II excludes traffic to and from the United States and the rest of the Caribbean from the total of Definition I.

[d]Definition III excludes traffic to and from Hawaii from the total of Definition II.

[e]Definition IV embraces the same geographical coverage of Definition III, but the figures of this column are based on the revised version of H. M. Flinn's estimates. Column I-III are based on Flinn's original estimates.

Sources:

Columns I, II, and II are calculated from estimates prepared for the American Telephone and Telegraph Company by H. M. Flinn.

Column IV is calculated from a revision of Flinn's estimates. The precise revision is given in the footnote on page 26 of this Memorandum.

Table 6

THE PROPORTIONS OF WORLD OVERSEAS TELEPHONE TRAFFIC CARRIED OVER PARTICULAR LINKS
(per cent)

Link	Definition I	Definition II	Definition III	Definition IV
North America-Europe	32.6	39.6	48.1	56.5
North America-Caribbean (other than Cuba and the Bahamas)	17.6	-	-	-
North America-Hawaii	14.6	17.7	-	-
North America-South America	7.2	8.7	10.6	10.8
North America-East and South Asia	4.4	5.3	6.5	7.6
North America-Australia and New Zealand	1.2	1.5	1.8	2.0
North America-Africa	0.3	0.4	0.5	0.5
Europe-Africa	4.4	5.3	6.4	3.5
Europe-Middle East and South Asia	3.1	3.8	4.6	4.0
Europe-Australia and New Zealand	1.3	1.6	1.9	2.3
Europe-South America	1.0	1.2	1.5	1.7
Europe-East Asia	0.5	0.6	0.7	0.8
Australia and New Zealand-East and South Asia	0.3	0.4	0.5	0.6
Japan-East and South Asia	2.7	3.3	4.0	2.5
Other Links	8.8	10.6	12.9	7.2
Total	100.0	100.0	100.0	100.0

Note:

The definitions of world overseas traffic and the sources of data are given in the notes to Table 3.

United States.* If Flinn's data are not adjusted, the relevant ratio is the 60 per cent figure implied by column III of either Table 5 or Table 6. The shares of the various areas and of the various routes in total overseas telephone traffic according to this revision of Flinn's estimates are presented as column IV of Tables 5 and 6. These figures apply to 1960. There are no reliable estimates of the total volume of telephone messages involving points other than the United States for other years, so there is little information as to the change through time in the relative importance of traffic involving the United States to total world traffic. However, since most of the overseas cables laid between 1956 and 1961 involve the United States at one terminus, it is likely that telephone service over routes involving the United States has been more improved than over other routes. As a consequence, the share of the United States in total overseas telephone traffic has probably been increasing over the base period, 1950-1962. As the Commonwealth cable system is put into operation and if Japanese cables are constructed, this trend may be reversed. The improvement of overseas telecommunications facilities over routes not involving the United States is but one element in this prediction. As measured by the number of telephones in use, the internal telecommunications systems of many foreign countries have been growing more rapidly than the internal telephone system of the United States in recent years. This is true for most of the European nations, Japan, India, South Africa, Australia, and Venezuela, to give but a partial list.

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*The estimates of column IV of Tables 5 and 6 are based on the following deductions from Flinn's totals: reductions for potential overcount: Europe-Middle East and South Asia (-30,000 messages), Europe-Africa (-100,000 messages), intra-area traffic in South Asia and the Middle East (-30,000 messages), South Asia-East Asia (-20,000); reductions for definition of coverage: West Indies and Central America-South America (-35,000 messages), intra-East Asian traffic (-50,000 messages). Although there is good evidence for the hypothesis that certain of Flinn's figures are too high, this evidence does not permit estimation of the size of this overcount with any great confidence. The adjustments for overcount are based on benchmarks obtained from the estimates by the British Post Office of overseas traffic involving South Africa, India, and Ceylon. Total traffic is defined to exclude traffic between the continental United States and Hawaii, between the United States and the Caribbean islands, and between France and Algeria.

THE GROWTH OF RECORD TRAFFIC THROUGH 1961

The importance of the market for record communication relative to the market for voice communication depends upon the question being asked. The gross revenue of the U.S. international telegraph carriers is greater than the gross revenue of the U.S. international telephone carriers. On the other hand, the bandwidth requirement for overseas telephone service exceeds the overseas bandwidths requirement of the telegraph carriers by a factor of something between six and seven to one. This ratio will increase somewhat in the near future.

The market for message telegraph service, the main source of income to the overseas telegraph carriers, has been growing very slowly and can be expected to continue to do so. Other forms of record communication have been growing at rates equal to or larger than the rate of growth of message telephone service, however, so it is possible that the decline of the relative importance of the record communication market will be arrested in the latter part of this decade.

Message Telegraph Service

The gross revenue derived from the message telegraph market still dominates the revenue totals derived from all forms of overseas record communication, but it is clear that message telegraph will play a much smaller role in the future overseas telecommunications market. In general, the growth prospects for message telegraph are sufficiently bleak that estimates of the additional bandwidth required to accommodate future increases in overseas telecommunications demand are not sensitive to the likely errors of forecast of the change of message telegraph demand.

The growth of overseas telegraph messages since 1950 is shown in Table 7. The average rate of growth (geometric mean) is only 2.3 per cent per year. The slow growth of message telegraph traffic is the result of a relative shift of demand to airmail, telephone, and telex services. Telex service has

Table 7

RECORD SERVICES PROVIDED BY U.S. INTERNATIONAL TELEGRAPH CARRIERS, 1950-1962

Type of Service	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962
Number of Overseas Telegraph Messages[a] (millions)	17.08	18.26	18.03	18.00	18.50	19.52	20.76	21.09	20.40	21.51	22.02	22.15	22.37
Revenue from Teleprinter Exchange Service (Telex) (millions of dollars)	-	-	-	-	-	-	1.88	2.83	3.55	5.22	7.36	9.74	12.17
Leased Circuit Revenue (millions of dollars)	1.06	1.95	2.81	3.66	4.29	4.77	5.34	5.95	6.81	8.36	7.49	8.62	10.34

Note:

[a]This total is defined as total foreign traffic less traffic between the United States and Canada, Mexico, Bermuda, the Bahamas, and Cuba plus traffic to Hawaii.

Sources:

Federal Communications Commission, Statistics of Communications Common Carriers, 1950 and subsequent years through 1961 (Washington: Government Printing Office) for years 1950-1961 and unpublished statistics from the files of the Common Carrier Bureau of the Federal Communications Commission for the year 1962.

the advantage of the greater flexibility inherent in duplex transmission. The quality of message telephone service has been improving consistently since World War II, and the ratio of telephone to telegraph prices has fallen about 10-15 per cent since the Korean War. Although there is no obvious way of distinguishing the relative importance of the growth of the various alternative means of communication to the decline in message telegraph, the statistics do suggest that the improvement of quality of telephone service is a factor of some importance. Message telegraph volume to Europe showed no change between 1956 and 1957, the first full year of operation of TAT-1, in spite of a sizable increase of transatlantic trade. During the first full year of operation following installation of the Hawaiian cable, the volume of message telegraph traffic between Hawaii and the continental United States fell some 6.6 per cent. Message telegraph traffic to Puerto Rico decreased 4.9 per cent in the year following introduction of cable telephone service. It seems reasonably safe, therefore, to predict a further slowing of the rate of growth of message telegraph service as telephone facilities of cable quality are extended to the Caribbean, South America, and the Far East.

Where total world overseas telegraph traffic is defined to exclude traffic between the United States and Alaska, Hawaii, and the Caribbean, and between France and Algeria, the total number of overseas telegraph messages appears to be about twice the volume of traffic involving the United States. For the same concept of overseas links, this can be compared with a ratio of about five to three in the case of message telephone. Traffic involving North America includes about 58 per cent of the total overseas message telegraph traffic. The corresponding figure for message telephone is approximately 71 per cent. The discrepancy in these figures is substantial and points up the fact that telegraph service to Europe from areas other than North America is relatively better than telephone service. The proportion of message telegraph volume that does not involve either North America or Europe is very small, probably on the order of 6 per cent or so, although this figure is subject to a fairly high absolute error.

About one-third of message telegraph service is directed between Europe and North America. The next most important traffic route is between Europe and Africa, with nearly 13 per cent of total intercontinental traffic even though this does not include traffic between France and Algeria. The volume of telephone calls between Europe and Africa was slightly less than 6 per cent of total intercontinental traffic. Roughly 10 per cent of message telegraph traffic involved the North America-South America link. Traffic between Europe and South America is apparently somewhat less than the traffic between North America and South America, although the ratio between North American and European traffic to South America in 1960 is almost certainly less for message telegraph service than for message telephone.

As is shown in Table 8, the pattern of distribution of message telegraph traffic is much closer to the pattern of world trade than is the pattern of distribution of telephone traffic. This is further borne out by comparisons of the traffic shares of particular links. About one-quarter of all intercontinental trade takes place along the transatlantic route. Transatlantic telegraph volume is about one-third of the world total while one-half of all intercontinental telephone traffic is so directed.

The data on changes in volume of world telegraph traffic through time are even less satisfactory than the data on the geographical distribution of this traffic. What information we do possess suggests that the very low rates of growth found for U.S. traffic are likely to be characteristic for telegraph traffic not involving the United States. Data for the United Kingdom, Belgium, and the Netherlands suggest that there may have even been an absolute decline in the volume of overseas telegraph traffic between Europe and intercontinental points other than the United States during the late 1950s. There seems to have been much less change in the pattern of distribution of message telegraph traffic during the past decade than in the pattern of distribution of telephone traffic. This also seems likely for the period up through 1970.

Table 8

DISTRIBUTION BY AREA OF OVERSEAS[a] TRAFFIC IN COMMODITIES, MESSAGE TELEPHONE, MESSAGE TELEGRAPH, AND TELEPRINTER EXCHANGE SERVICE (TELEX)
(per cent)

Area	Type of Traffic			
	Commodity Trade (1960)	Message Telephone (1960)	Message Telegraph (1960)	Telex (1962)
United States	(37)	(60)	(50)	(57)
North America	47	71	58	63
Europe	64	66	69	64
South America	17	13	18	17
Africa	16	9	17	9
Middle East	12	3	7	2
South Asia	16	9	9	3
Japan	12	9	10	30
East Asia other than Japan	8	11	4	6
Australia and New Zealand	8	9	8	6
Total	200[b]	200	200	200

Notes:

[a]"Overseas" traffic is defined so as to exclude traffic between the United States and Alaska, Hawaii, and the Caribbean, and traffic between Europe and North Africa.

[b]The percentage figures for each area total to 200 per cent because there is no distinction made between initiation and termination of traffic.

Sources:

Commodity Trade: United Nations, Yearbook of International Trade Statistics, 1960 (New York: United Nations, 1962).

Message Telephone Service: Estimates by H. M. Flinn prepared for the American Telephone and Telegraph Company. Message Telegraph Service: International Telecommunications Union, General Telegraph Statistics, 1958 (Geneva: ITU, 1959).

Telex Service: International Telecommunications Union, Development of the International Telex Service (Geneva: ITU, 1962).

Telex and Leased Line Record Services

Although message telegraph traffic has been growing slowly over the past decade, other forms of record communication have been growing at rates equal to or in excess of the rate of increase of voice communication. The sum of the leased circuit and telex revenues of the U.S. international telegraph carriers has grown at the average* annual rate of 20.9 per cent since 1956. The growth of telex traffic has been particularly high, the average rate of increase in telex traffic involving the United States having been about 35 per cent per year since 1956. Telex revenue prior to 1956 is not identifiable from published FCC records, but ITU data suggest that the average rate of increase of telex traffic was about 60 per cent per year during the period 1951-1956.

New services can be expected to grow at more rapid rates than existing services, particularly when a deferred demand has been building up for a period of years. The experience of other nations suggests that this is the case with the growth of telex. Telex traffic to Argentina was initiated in 1957, the rate of increase of traffic falling from 133 per cent in 1959 to 41 per cent in 1961. Japanese telex service was initiated in 1956, the rate of growth of traffic falling from 97 per cent in 1958 to 42 per cent in 1961. Overseas telex service to Canada seems to have commenced during 1957, the rate of increase of telex service falling from 118 per cent in 1959 to 16 per cent in 1961. Telex volume to and from the European countries is primarily intra-European in routing, but growth rates are falling. The rates of increase in 1955 for France, Germany, and Sweden were 38.9, 30.1, and 21.3 per cent. By 1961 these rates of increase had fallen to about 24, 11, and 5 per cent respectively.

Such a slowdown in the rate of increase of overseas telex traffic is also evident in the recent U.S. traffic experience. An important complication in identifying such a reduction is the sensitivity of telex traffic to the volume of intercontinental trade.

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*Geometric average.

The years 1955-1957 were years of substantial increase in the volume of intercontinental trade with the United States, 1956 being the peak year. The high rates of increase of telex traffic for these years, 59, 56, and 51 per cent chronologically, partly reflect this trade expansion. The slump of trade in 1958 was accompanied by a reduction in the rate of growth of telex traffic to 25 per cent. The return to a rate of increase of telex traffic of 54 per cent in 1959 is coincident with the resumption of a rapid rate of growth of intercontinental commodity trade. The data for 1960-1962, however, seem to show a somewhat smaller rate of increase of telex traffic than might have been predicted from the rate of increase of trade. In spite of a strong increase in trade during 1960, telex traffic increased only 35 per cent. A rate of 50 per cent would have been consonant with the relationship between trade and telex growth rates for the period through 1959. The rate of increase of telex traffic slipped still further to 32 per cent in 1961, although this is a fairly small reduction when the trade recession of 1961 is considered. These year-to-year rates of increase apply to the total number of chargeable minutes of telex transmission. A comparable statistic for 1962 is not available, but rates of increase of total revenue derived from telex transmission and rates of increase of the total number of chargeable minutes of transmission are quite similar, and the rate of increase of telex revenue in 1962 was only 25 per cent.

The rate of increase of revenue from leased line service has been more moderate but is still greatly in excess of the rate of growth of message telegraph traffic. In the period 1956-1962, the average rate of growth of leased line revenue was 11.6 per cent per year. In the period 1951-1956 leased line revenue increased at the average annual rate of 22.3 per cent. The difference in the rate of growth of leased channel revenues between these two periods is due in part to the cancellation of certain leases by the government during 1960. During this year the government transferred most of its leased line traffic from circuits offered by the telegraph carriers to circuits derived from the transoceanic telephone cables.

Ignoring the revenue changes during 1960, leased line revenue increased at the average yearly rate of 16.4 per cent.*

In large part, the growth of telegraph carrier revenues are attributable to the growth of telex and leased line revenue. The increase of nearly $20 million in revenues from telex and leased line services was about half of the increase of total operating income reported by U.S. international telegraph carriers during the last ten years. Telex and leased line revenue is now 35 per cent of total message service revenue, and the number of circuits used for telex service is apparently a similar proportion of the number of circuits available for message traffic.

The estimates of the present world distribution of telex traffic in Table 8 are derived from ITU figures for numbers of revenue minutes of incoming and outgoing telex traffic during January 1962. In addition to the usual errors of reporting there is a problem of potential bias connected with differences in the pattern of seasonal variation in telex traffic. According to these estimates, the global distribution of telex traffic is somewhat similar to the distribution of message telegraph traffic, although certain areas of the world have not yet been provided with telex service comparable in quality to telegraph service. About 63 per cent of all overseas telex traffic involves North America, 57 per cent being incoming or outgoing traffic from the United States. The North Atlantic link handles nearly one-third (32 per cent) of all traffic. Traffic to and from Europe accounts for about 64 per cent of total overseas traffic, and traffic not involving either North America or Europe is only about 7 per cent of all traffic. Next to the North Atlantic link in importance is the link between North America and Japan, with over 16 per cent of total overseas traffic. Japan handles a larger volume of telex traffic than any other country except the United States, with about 30 per cent of all telex messages either originating in or terminating in Japan.

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*A geometric mean.

From the point of view of revenue, the remaining record services are of little importance to the U.S. international telegraph carriers. A small traffic in facsimile transmission exists, but it has grown slowly. However, such transmission has been at very slow speeds because of the narrow bandwidth of the standard 60 wpm telegraph channel. The current insignificance of facsimile transmission need not be characteristics of a future in which high speed facsimile transmission is possible. Slow speed data transmission has been offered in conjunction with telex services for some time. High speed (1,500 wpm) service on an overseas basis was not inaugurated until September 1962, when a datatelex circuit with a capacity of 1,500 wpm (1,200 bits/sec) was inaugurated across the North Atlantic. There is every reason to believe that the demand for high-speed data transmission will grow rapidly during the next decade. Rapid growth in this market may be expected to offset to some extent the decline in the rate of growth of conventional telex traffic so that bandwidth requirements for record services may be growing as rapidly as the requirements for overseas voice communication by the late 1960s. Revenue from telex, datatelex, facsimile, and leased line markets seems likely to exceed the revenue derived from message telegraph after 1965-1966. For the entire period 1962-1970 it seems doubtful that the average yearly increase in record traffic (and hence bandwidth requirements) will exceed 12 per cent. This prediction is based on the assumption that telex and datatelex traffic growth will continue at rates of not less than 20-25 per cent. It seems likely, therefore, that the relative importance of the message telephone market with respect to future bandwidth requirements will continue to increase.

IV. THE GROWTH OF THE MARKET FOR CONVENTIONAL TELECOMMUNICATIONS SERVICES THROUGH 1970

The set of estimates of capacity requirements for 1970 presented in Table 1 rest on the following general assumptions. First, some time before 1970 overseas telecommunications facilities will be constructed in such quantity that waiting time on service to overseas points will not be grossly in excess of waiting time on toll circuits within the continental United States. Second, the network of direct overseas telephone links will be approximately as dense as the present network of direct overseas telegraph links. Third, the change in the relative price of telecommunications services will continue to decline at the rate of one or two per cent per year. The implications of somewhat less strict assumptions about service quality and density of the telephone network are examined below. The question of the effect of a substantial reduction in the relative price of telecommunications services is beyond the scope of this Memorandum.

The estimates of this section do not include estimates of the capacity that might be required for broadcast or conference television on overseas links or for facsimile transmission of overseas mail. These markets will be treated in Section V.

THE CONVERSION OF ESTIMATES OF MESSAGE DEMAND INTO CAPACITY REQUIREMENTS

There is no generally satisfactory method of converting figures for number of messages into numbers of circuits required even when a given quality of service is assumed. The conversion factor is sensitive to many things: the time distribution of demand over the day (which is chiefly related to the time difference between the two points of the link); the proportion of station calls to person-to-person calls; the adequacy of domestic switching facilities; and the type of switchboard service (direct dialing, direct operator dialing, operator-operator service, and so on). The following attempts to provide such conversion factors should be viewed with the above warning in mind.

For a time distribution of demand similar to that observed for transatlantic traffic, telephone service of a quality associated with an average queueing period (queues during peak periods will be considerably longer) of about 15-20 minutes can be obtained with a traffic load of from 30 to 35 calls per day (9,000 to 10,500 per year)* per full-time voice circuit if the circuits are of cable quality in terms of signal-to-noise ratio. The average length of message is assumed to be 7-1/2 minutes. For the same time pattern of demand, service of something like domestic quality (close to zero average waiting time) could be obtained with a load of 20-25 calls per circuit. The latter figure is somewhat uncertain in that the increase in demand associated with improvement of circuit quality to domestic standards is not subject to precise estimation. The target set by AT&T for transatlantic traffic is 25 calls per circuit per business day with direct operator dialing (estimated as equivalent to 21-23 calls per day with present techniques).

These figures represent something of an average value for traffic density figures considered for all overseas links involving the United States when a high quality of service is assumed. Service to points such as Puerto Rico and Hawaii can be maintained at a quality approaching that for domestic links with somewhat higher load factors, perhaps 30 calls per day per circuit, because of the greater overlap of business hours with the continental United States. Service to Japan with negligible average waiting time will be assumed to require a load factor of approximately 20 calls per day because of the time differences involved. Despite the absence of a significant time differential, excellent service on Latin American links may not be possible because of deficiencies in local trunk capacities that are likely to persist over the time span of this forecast.

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*Estimated on the basis of 300 full-time traffic-days in a year.

FORECASTS OF DEMAND BY OVERSEAS ROUTE

Transatlantic Traffic Involving the United States

The assumptions behind the estimates of capacity requirements for telecommunications between the United States and Europe are reasonably straightforward. During the trade peak-to-trade peak period 1951-1962 the trend in the annual rate of increase of the number of telephone messages between the United States and European points was about 17 per cent. From 1953, the final year of the Post-Korean war trade recession, to 1961, a year of relatively little growth in transatlantic trade, the annual rate of increase in the number of telephone messages over these routes averaged nearly 20 per cent. Since a rate of traffic increase is desired that is suitable for extrapolation, several additional factors must be taken into consideration. First, the average length of message has been increasing. Second, the quality of service has improved, with respect to both waiting times and quality of signal. During the period 1953-1961 the trend or "normal" rate of increase of revenue was over 24 per cent per year, implying an average rate of increase in length of message of some 4 per cent per year. Much of this increase in message length can be attributed to the once-and-for-all effect of the changeover from HF radiotelephone circuits to cable circuits. Ignoring these increases, the "normal" rate of increase in length of message has been on the order of 2 per cent per year.

The importance of the reduction in average waiting time is more difficult to estimate quantitatively. On the basis of examination of customer response to the reduction of waiting time on circuits to the United Kingdom in the year following completion of TAT-1 and the response on circuits to France and Germany following installation of TAT-2, it appears that some 20-30 per cent of the increase in the number of transatlantic telephone messages in the period 1956-1960 can be attributed to the reduction of waiting time.* After adjustment

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*The reduction in queueing time during this time period for most transatlantic circuits was on the order of 25-30 minutes. Customer

for the response to the reduction of waiting time, the long-term rate of increase of the number of telephone messages between the United States and Europe calculated for the 1953-1961 trade period is 16-17 per cent. The same adjustment of the trend estimated for the 1951-1962 trade period yields a "normal" growth rate of 14-15 per cent per year. When the 2 per cent average rate of increase of message length is taken into account, the estimates of the long-run "normal" annual rate of increase of traffic calculated for the periods 1951-1962 and 1953-1961 are 16-17 per cent and 18-19 per cent respectively.

Assuming traffic growth at the average annual rate of 16-19 per cent, and assuming that the current quality of service is maintained, the estimated demand for transatlantic telephone messages in 1970 is 4.8-5.9 million "messages." The distinction between "message" and message refers to the presumption that the average length of actual messages will continue to increase, the above calculation being stated in terms of message units or "messages" of 7-1/2 minutes, the current average length of transatlantic telephone conversations.

Since the quality of service obtainable at present is achieved with traffic density figures of something like 30-32 calls per day or 9000-9600 calls per year per full-time circuit, the capacity requirement for message telephone service implied by the estimated demand of 4.8-5.9 million "messages" is about 500-650 voice trunks. If average waiting time is reduced to one or two minutes -- a reduction of some 10-20 minutes on most circuits -- the quantity of telephone service demanded is likely to increase an additional 10-20 per cent. Since this higher quality service can be achieved only through reduction of traffic density to about 25 calls per circuit per day or 7500 calls per year, the capacity requirement estimates are increased to 700-950 voice trunks.

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response over those routes affected by the construction of the submarine cables TAT-1 and TAT-2 suggests that the number of messages will increase 8-10 per cent for every ten minute reduction in average waiting time. The latter estimate was obtained by comparing traffic flow before the switch from HF radiotelephone to cable facilities with traffic flow immediately following the changeover.

The estimate that the total capacity requirements for transatlantic record services is likely to be equivalent to some 60-80 3 kc voice channels is based on the following assumptions: message telegraph demand will increase at the average rate of 1-2 per cent per year; leased line demand will increase at the rate of 15 per cent per year; and telex and datatelex demand will increase at the average annual rate of 20-30 per cent.

The estimate of government demand for leased circuits results from little more than the need to fill an empty box. At the end of 1962 the government was leasing 28-1/2 voice channels derived from the transatlantic telephone cables. If the policy of switching from military-operated radiotelephone circuits to cable circuits of a higher grade continues, the estimate of 64-96 voice channels to be required by the government does not seem unreasonable. Given the underlying assumptions about the price of leased bandwidth and quality of message telephone service it does not seem likely that a significant demand for leased telephone channels on transatlantic routes will arise from private business.

Transpacific Traffic Involving the United States

The capacity requirements for transpacific traffic can be estimated with considerably less confidence than for transatlantic traffic. One major uncertainty is the extent to which voice communication can substitute for duplex record communication. For example, given the characteristic quality of signal on HF radiotelephone circuits, Americans have apparently had much difficulty in understanding the heavily accented English that is often characteristic of Japanese who have not had language training abroad. This is one reason why telex traffic to Japan has grown so much more rapidly than telephone traffic. Message traffic to Japan is considerably less in volume today than during the Korean War peak. Since the reduction of the number of U.S. military personnel stationed in the Far East was substantial during this period there is no growth rate to be obtained

from examination of the records of the past decade that can be described as of much relevance to predictions of the future.

The growth prospects for the various transpacific routes appear to be quite different. The estimated channel requirement for the link between the United States and Australia-New Zealand is obtained from the following assumptions. Since average waiting time on circuits to Australia is now about 25 minutes, improvement in quality of service is likely to induce an increase of from 20 per cent to 40 per cent in the number of messages demanded. In addition, the average length of message is likely to increase by about 20 per cent as a result of improvement of the signal-to-noise ratio. If a "message" is assumed to be of the current average length, the number of "messages" demanded is likely to increase by some 45-70 per cent as a result of the reduction of waiting time and improvement of quality of signal. Further assuming a "normal" yearly rate of increase of traffic (paid minutes) of 14-16 per cent,* the 1970 traffic volume will total some 135,000-180,000 "messages." The quality of service assumed in this projection is presumed obtainable with a traffic load of about 6000 calls per year per channel, a low figure that reflects the extreme time differential between the United States and Australia. The channel requirement for message telephone service in 1970 therefore reduces to some 23-30 voice channels. Since it is doubtful that the number of channels demanded by the telegraph carriers could exceed a total of 4-5 voice channel equivalents, the aggregate capacity requirement from the United States to Australia-New Zealand is about 30-35 voice channels.

Perhaps the least predictable submarket is that between the United States and the Far East. The number of telephone messages between the United States and Japan actually declined in the period 1953-1961. The reduction of the number of U.S. military personnel

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*The long-term trend in the rate of growth of the number of telephone messages to Australia-New Zealand calculated for the trade period 1951-1962 is about 12 per cent. The trend calculated for 1953-1961 is about 13 per cent.

in Japan is an important factor behind this decline. Since average waiting time on circuits to Japan is now on the order of 35 minutes and since these circuits are obtained from HF radiotelephone facilities, the combined effect of reduction in waiting time and improvement in signal quality could be a once-and-for-all increase of some 50-70 per cent in the volume of traffic. Further assuming a 6-10 per cent per year "normal" rate of increase of traffic, the volume of telephone traffic to Japan in 1970 will total some 200,000 to 330,000 messages. To obtain the quality of service assumed in these estimates, a traffic load factor of some 20 calls per day per trunk or 6000 per year is assumed. The capacity requirements for message telephone service between the United States and Japan in 1970 are thus estimated as being 33-55 voice trunks.

The estimates of the capacity required to accommodate the demand for telephone service to other East Asian points are scaled to the estimates of traffic to Japan. Approximately half of the total number of telephone messages between the United States and East Asia is now accounted for by the traffic to points other than Japan. The average yearly rate of increase of the number of messages to such points over the period 1951-1962 has been about 5 per cent. Waiting times on these circuits in 1962 were quite long: 50 minutes to the Philippines; 45 minutes to Korea; and 45 minutes to Okinawa. Assuming a 50-70 per cent increase in traffic as a result of improvement of quality of signal and reduction of waiting time and a 6-10 per cent "normal" yearly rate of increase of traffic (paid minutes), the demand for telephone service to points in the Far East other than Japan will be such as to require some 32-53 voice trunks.

The capacity required for record services to the Far East in 1970 is quite problematical. The provision of higher-quality telephone service is likely to depress the rate of growth of telex traffic to this area somewhat, but the language problems will continue to inhibit the use of voice communication. Assuming the rapid development of a market for datatelex transmission between the United States and Japan, the capacity requirements for record transmission to the

Far East will be about one-fourth or one-fifth of the total requirements for voice communications, or some 17-23 voice channel equivalents.

Government demand is very difficult to predict. At one time the military planned to lease 35 channels in a cable from Guam to Okinawa, but the plans for this cable have been postponed indefinitely. Government demand for leased channels on the cable west of Hawaii are assumed to total 48-64 channels.

The future capacity requirements for message telephone service between the continental United States and Hawaii can probably be predicted with less error than those for the other transpacific links. The regression estimates of the average rate of growth of the number of telephone messages between the continental United States and Hawaii for the trade periods 1951-1962 and 1953-1961 are about 19 per cent and 21 per cent respectively. Data on the reduction of waiting time over these periods is not available, but if the regressions are adjusted to eliminate the effect of the increase in traffic in the year following the completion of the Hawaiian cable, the estimates of the "normal" annual rate of increase of the number of messages are reduced to 16-17 per cent for the period 1951-1962 and 17-18 per cent for the period 1953-1961. When the trend in the annual increase in length of message is taken into account, the "normal" increase in traffic appears to be on the order of 18-20 per cent.

Projecting 1962 traffic figures at 18-20 per cent gives an estimate of the number of telephone "messages" to Hawaii in 1970 on the order of 2.5-3.0 million. The quality of service at present characteristic of Hawaiian traffic is obtained with a traffic density in excess of 30 calls per day per trunk. If waiting time is to be reduced to the standard assumed here the traffic load must be somewhat lower, perhaps 28 calls per day per trunk or 8400 calls per trunk per year. Assuming that this improvement in quality of service would lead to a further increase in traffic of some 10 per cent, the capacity requirement for message telephone service to Hawaii will be between 325 and 390 voice trunks in 1970.

The capacity requirements for record services between Hawaii and the mainland are likely to be less important relative to the requirements for voice communication than for most of the overseas links involving the United States. The bulk of this will probably take the form of a demand for leased record circuits, total record telecommunication requirements being estimated at no more than 15-20 voice channel equivalents.

U.S. Traffic to the Caribbean and South America

Since 1950, telephone message volumes to the various countries of this area* have grown at exceedingly diverse rates. The average rates of growth vary by country from a high of over 25 per cent per year for Puerto Rico to a low of less than 2 per cent for Brazil. The rates of increase are inversely related to the distance from the United States. Traffic to Puerto Rico and Jamaica has increased at the average yearly rate of 24-25 per cent. Traffic to the Central American countries other than Panama has increased at something more than 10 per cent per year. Traffic to Panama, Colombia, Venezuela, and Ecuador has increased at the average yearly rate of slightly more than 6 per cent, and traffic to the remaining countries of South America has increased at the rate of only 4 per cent per year. These differences reflect the fact that the rate of growth of trade between the United States and the Caribbean nations is considerably higher than the rate of growth of trade between the United States and the remaining countries, as well as the great increase of tourist traffic concentrated in the islands of the Caribbean.

Although the relative pattern of growth of telecommunications traffic between the United States and the various overseas points of this hemisphere is likely to be maintained in the future, the absolute growth rates characteristic of traffic to many of these countries reflect certain conditions that may not or need not hold true in the

*For purposes of this discussion the Caribbean traffic area is defined to exclude Bermuda, Cuba, and the Bahamas because of the short distances involved.

future. Part of the reason for the very low rates of increase of traffic between the United States and South America has been the slump in the overseas commodity trade of the South American countries that has persisted since the end of the Korean War. The growth of telecommunications traffic has also been held back by the crowding of overseas and domestic circuits. Improvement of the domestic telecommunications networks in these countries is as essential as the increasing of capacity on overseas links if higher quality overseas service is to be made available. However, there seems no reason to assume that the pace of economic growth in Latin America will dramatically accelerate in the coming decade, nor is there reason to believe that tourism to South America is likely to grow at a very high rate. The historical rates of growth of telecommunications traffic to many points in this area do seem somewhat low for the purposes of extrapolation, but the fact that they have been low in the past reflects certain continuing facts about the growth potential of this market.

In the absence of unexpected improvements of internal telecommunications systems or unexpectedly high rates of growth of output, it does not seem likely that the long-term "normal" rate of increase of telephone traffic to the countries of central and southern South America will exceed 6-8 per cent. This implies a total of some 180,000 to 220,000 telephone messages between the United States and these countries in 1970. This estimate presumes no change in quality of service. Since waiting times on the circuits to these points are now quite high -- 25-30 minutes -- a substantial response to improvement of quality of service to the levels assumed in this Memorandum can be expected. Assuming a 20 per cent increase in average length of message because of improvement in signal quality and an increase in the number of messages of 50-65 per cent as a result of reduction of waiting time on overseas and domestic circuits, the potential demand for message telephone service of high quality to this area in 1970 is about 320,000 to 450,000 "messages." With a traffic density target of 25 calls per circuit per day or 7500 per year, the estimated

capacity requirement for message telephone service reduces to about 40-60 voice channels.

The growth prospects for the market for telecommunications services between the United States and the countries of Central America and northern South America are somewhat brighter than the market prospects for telecommunications to the other South American countries. The average waiting time on circuits to these countries was very high in 1962 -- 35 minutes to Venezuela, 55 minutes to Colombia, and 60 minutes to Panama. It does not seem unreasonable, therefore, to assume an increase of traffic volume of 80-100 per cent to Colombia and Panama and an increase of 60-80 per cent in traffic to Venezuela and Central America in response to the improvement of quality of service. Further assuming an 8-12 per cent long-term yearly rate of increase of traffic, the total volume of telephone traffic to this area will be some 660,000 to 1,070,000 messages in 1970. For a traffic density target of 25 calls per day per trunk the total capacity requirement becomes 90-145 voice channels.

The most rapid rate of growth of telecommunications traffic between the United States and overseas points in the western hemisphere will almost certainly continue to occur over certain of the routes between the United States and the Caribbean islands. Regression estimates of the average annual rate of growth of telephone message volume to Puerto Rico for the periods 1951-1962 and 1953-1961 are 24.6 per cent and 24.7 per cent respectively. If the regressions are recomputed so as to eliminate the effect of the traffic increase in 1960, the year following the introduction of cable service to Puerto Rico, the estimates of the "normal" rates of increase of the number of telephone messages are 21-22 per cent and 19-21 per cent for these two trade periods. Accepting these figures as estimates of the future trend and assuming an annual rate of increase of message length of 2 per cent, the volume of telephone traffic to Puerto Rico will increase at the rate of 21-24 per cent per year. A very similar rate of increase of traffic to Jamaica can be expected.

Extrapolating the current volume of Puerto Rican traffic at the annual rate of 21-24 per cent and assuming that improvement of quality of service would lead to a 5-10 per cent increase in traffic, the estimate of the volume of telephone traffic between the United States and Puerto Rico is 3.0-3.8 million "messages." Given the target of 30 calls per day or 9000 calls per year per trunk, the capacity requirement implied by this demand estimate is 330-420 voice trunks.

Traffic Between the United States and Other Areas and Traffic Not Involving the United States

Traffic to Africa, the Middle East, and South Asia totalled some 1.5 per cent of all overseas telephone traffic involving the United States and about 10 per cent of total message telegraph traffic to and from the United States. If traffic between the United States and Hawaii or the Caribbean area is excluded, the relevant ratios are about 2.6 per cent and 11 per cent respectively. The lack of direct circuits to most points in these regions has placed a severe constraint on the growth of message telephone traffic and has provided some stimulus to the growth of message telegraph service. If the relative attractiveness of record and voice communication to these areas were the same as on the transatlantic routes, perhaps as much as 4-5 per cent of United States overseas telephone traffic (traffic to Hawaii and the Caribbean excluded) would be directed to African, Middle Eastern, and South Asian routes by 1970. Under this assumption the total capacity requirement for message telephone service to these areas in 1970 will be 35-55 voice channels.

Limitations on the availability of data require a similarly rough basis of estimation of the capacity required to accommodate the demand for overseas telephone service not involving the United States. Excluding traffic to Hawaii and the Caribbean islands the volume of U.S. overseas telephone traffic in 1970 is estimated at 7.0-9.8 million messages. In Table 5 it was noted that the number of telephone messages not involving the United States can be estimated somewhere between 31 and 40 per cent of the total volume of overseas traffic if the

traffic from the continental United States to Hawaii and the Caribbean area is excluded. These figures apply to 1960. The upper estimate is the ratio calculated from the traffic estimates prepared by H. M. Flinn. The lower estimate is the ratio calculated from the revision of Flinn's estimates which was described in Section III. If the distribution of world traffic in 1970 should prove to be the same as in 1960, the total number of overseas telephone messages in 1970 not involving the United States would be about 4.6-6.5 million or 3.2-4.5 million depending upon whether the original or revised version of Flinn's estimates is accepted.

However, it is quite possible that the volume of telephone traffic not involving the United States will increase somewhat more rapidly than the volume of U.S. traffic. At the moment, telephone service over routes not involving the United States is more likely to be provided by indirect circuits than is service to the United States. The number of telephones is increasing more rapidly in many foreign countries than in the United States. If telephone service of excellent quality were to be provided between most foreign points that are now linked with direct telegraph circuits, it seems quite reasonable to conclude that there would be a shift from telegraph to telephone service and that the differences in the patterns of distribution of telephone and telegraph traffic over the world would tend to diminish. The fact that about 50 per cent of world telegraph traffic does not now involve the United States, whereas only 31-40 per cent of telephone traffic is so routed, is at least partially the result of differences in the relative quality of voice and record services on foreign links as compared with links to the United States. Given substantial improvements of quality of telephone service over links between foreign points, it is possible that the ratio of the number of overseas telephone messages over foreign links to the total number of all overseas telephone messages (U.S. traffic to Hawaii and the Caribbean excluded) will increase from .40 to .43 or .42 (given Flinn's original estimates) or from .31 to .35 or .33 (given the revised version of Flinn's estimates). The extent to which the proportion of overseas traffic

involving the United States to all overseas traffic can be expected to decline depends upon whether the upper or lower estimates of total U.S. overseas traffic are accepted. If the higher figure for U.S. traffic is assumed, the lower estimate of the proportion of foreign traffic to total traffic is relevant.

On the basis of these assumptions as to the ratio of foreign traffic to total world traffic, the volume of telephone messages in 1970 not involving the United States will be about 5.3-7.1 million or 3.8-4.8 million messages. The first estimate corresponds to Flinn's original estimates of the volume of overseas telephone traffic in 1960. The second estimate corresponds to the revised version of his estimates. Assuming that the traffic density over these routes that is compatible with the assumption of very low average waiting times averages 25 messages per day or 7500 messages per year per trunk, the capacity requirement implied by the above estimates of potential traffic is 700-950 or 500-650 voice trunks. Since it seems highly likely that Flinn's original estimates of traffic over certain foreign routes are too high, the smaller set of potential requirements seems the more defensible and is used as the estimate in Table 1.

V. THE DEMAND FOR BROADBAND CHANNELS

For purposes of this discussion, a "broadband channel" is a channel of greater bandwidth than required for one cable voice channel. "High-speed transmission" is transmission of information at a time rate in excess of that currently possible over the bandwidth of one cable voice channel.

The estimates in Table 1 include the requirements of all telecommunications services other than television transmission and commercial demands for channels of a bandwidth in excess of one cable voice channel. With respect to these excluded markets, it is estimated first that the commercial demand for broadband channels in 1970 will be negligible; and second, that the effective demand for television transmission in 1970 will not warrant the provision of this service on routes other than the North America-Europe and North America-Hawaii links. Further, it is doubtful that the effective demand for television transmission over these routes will be sufficient to warrant the supply of this service except on an off-peak basis.

The conclusion that the commercial demand for broadband channels will not prove to be of significance in 1970 is consistent with the widely held presumption that the volume of overseas transmission of business data will increase dramatically as the facilities for such communication are improved. A substantial market for record transmission at rates from 600 to 2400 bits per second or 750 to 3000 words per minute will undoubtedly develop by 1970. By current standards such traffic is classified as "high-speed" data transmission, but the bandwidth required for transmission at these time rates is less than or equal to one cable voice channel. In almost all cases the overseas communications needs of the private sector in 1970 that are likely to derive from business procedures requiring centralized processing of information by computer systems can be accommodated by part-time use of datatelex channels derived from a cable voice channel or part-time use of a voice channel. The information requirements of the computer systems commonly employed by business are such that only the linking

of computers for joint problem solution would create a rate-of-information-flow requirement that could not be satisfied over one voice channel.

The rate-of-information flow required by customers on domestic circuits can ordinarily be expected to be higher than the rate of flow needed for overseas links, yet the great bulk of the demand for equipment designed to translate machine data into transmission code is concentrated in the market for low-capacity equipment. Most of the users of AT&T's dataphone systems have acquired the slow-speed (75 bits per second) equipment designed to use the bandwidth of one telegraph channel. The modest information requirements of private users of overseas telecommunications facilities relative to domestic requirements have apparently led AT&T to conclude that there will be no effective private demand for the overseas equivalent of the broadband channels offered domestically under the Telpak tariff. In the domestic market the bulk of the demand for broadband channels now comes from the government. A study done for AT&T estimated that some 70 per cent of Telpak revenue in 1970 will come from the government. The commercial demand for Telpak services will come mainly from industries whose productive process can be characterized as a continuous flow. Petroleum refiners, distributors of natural gas, producers and distributors of electricity, and the railroads and airlines will furnish the bulk of the commercial demand for domestic broadband telecommunication services. Only the demand by the airlines is relevant to overseas demand.

The conclusion that the commercial demand for broadband overseas channels will not be significant in 1970 is thus an estimate of the form that business demand will take rather than an estimate that such demand will not grow rapidly. The estimates of the bandwidth likely to be required for record services made in the previous section were based on the assumption that the revenue derived from the provision of record services other than message telegraph will continue to grow at something like the very high rate observed over the past decade.

This assumption is in turn warranted only under the further presumption that rapid development of the new market for data transmission will compensate for the inevitable decline in the rate of growth of overseas telex traffic.

An additional reason for believing that business use of broadband channels is likely to be of secondary importance is the imminence of improvements in terminal equipment that will reduce the bandwidth required for a given rate of flow of information. At present a datatelex channel derived from one cable voice channel provides service at a rate of digital flow of 1200 bits per second or some 1500 words per minute. However, transmission at a rate of 2400 bits per second is possible with currently available terminal equipment, and transmission at about 5400 bits per second over the bandwidth of one cable voice channel has been achieved under laboratory conditions. The military has expressed a desire for channels that would permit transmission at the rate of 40.8 kilobits per second. Whether or not the bandwidth to be used to provide for such a capability will be equivalent to the 16 voice channels originally assumed or whether there will be a saving of bandwidth through use of more advanced terminal equipment is uncertain. There is also the possibility that voice communication will be digitalized by 1970. From the standpoint of estimates of future bandwidth requirements the importance of these technological developments is that increases in the efficiency of bandwidth use seem likely to keep up with, or perhaps exceed, the increases in demand for transmission of information. Although such major changes as the transmission of voice communication in the form of binary data are not likely to be commercially feasible within the time span of this forecast, improvement in the equipment translating machine language into tone signals compatible with transmission over the telephone network is being carried out at the moment.

The one market development that would totally falsify the previous conclusions as to the telecommunications capacity required for record communication in 1970 would be the widespread use of facsimile transmission for distribution of mail. The bandwidth required for

teletransmission of even a small fraction of total overseas mail would be substantially greater than that required for all other record services. A forecast of the domestic bulk communications market made for AT&T suggests that the revenue derived from facsimile transmission of domestic mail would be on the order of seven and one-half times the revenue derived from broadband circuits provided to the private sector and over twice the revenue derived from the provision of broadband circuits to all potential users other than the United States Post Office in 1970. Given a similar set of assumptions it seems likely that bandwidth roughly equivalent to 400 cable voice channels would be required for facsimile distribution of overseas mail if it were to prove economically efficient to do so. The combination of improved overseas airmail service likely to result from the introduction of commercial supersonic flights and the relatively high cost of bandwidth to overseas points makes it highly unlikely that a telecommunications requirement deriving from facsimile distribution of overseas mail will develop by 1970.

The estimate of 400 voice channels as a potential requirement for provision of facsimile transmission of mail is based on the assumption that the rate of growth of overseas airmail in the period 1960-1970 will be the same as during the period 1950-1960, and that the volume of mail between the United States and foreign points susceptible to facsimile distribution is equal to 9 per cent of that total. The figure of 9 per cent is the estimate by the Post Office of the proportion of domestic first class mail susceptible to facsimile distribution. On these assumptions some 30,000,000 pieces of international mail would be so distributed. The previously mentioned forecast assumes that each piece of mail is equivalent to 1,000,000 binary digits for purposes of facsimile transmission, which implies a total facsimile transmission requirement of 30×10^{12} bits per year. Since this is a total information requirement the bandwidth requirements on particular links would be highly variable, ranging from perhaps 4 to 400 kc, but summing to a total roughly estimated as equivalent to 400 voice channels. This estimate should not be considered anything but an

indication of the order of magnitude of the bandwidth required for overseas facsimile mail, the facsimile distribution and the conversion factor relating pieces of mail to information requirements both being subject to question.

Since it is doubtful that domestic mail will be distributed by facsimile by 1970 on any but an experimental basis, facsimile distribution of foreign mail seems even more doubtful. The specification for domestic facsimile distribution set by the Post Office requires transmission at a cost of no more than $.01 per million bits. Assuming a rate-of-information flow of 8×10^{12} bits per year over a 400 kc channel and a maximum acceptable cost of overseas transmission of $.05 per million bits, the maximum acceptable price for the full-time lease of such a 400 kc channel is $400,000 per year or roughly $4,000 per year per equivalent voice channel. It is highly improbable that the cost of bandwidth could be reduced to this level within the time horizon of this study, and the improvements in speed of overseas airmail that will come with commercial supersonic aircraft will likely put a firm ceiling on the maximum acceptable cost of transmission.

The strength of the demand for overseas transmission of television is exceedingly difficult to predict. It can be expected that the reactions of the television networks toward this eventuality are somewhat mixed -- interest in the programming that would be made possible with direct transmission offset by concern over the substantial costs of such transmission. The rather complex competitive structure of the network television oligopoly further intensifies the uncertainties as to the future of the market for this service. The suspicion here is that television will be transmitted over overseas links during peak hours only if the common costs entailed in providing aggregate bandwidth are not allocated among the various telecommunications services according to their bandwidth requirements. Overseas television transmission in 1970 is more likely to be limited to transmission during off-peak hours and then only if the price of the necessary bandwidth is substantially less than the price of a full-time or peak-time lease. Even with the proviso that television transmission be limited

to hours that are off-peak with respect to telephone demand it seems likely that overseas television transmission will be confined to the continental United States-Hawaii and North America-Europe links in 1970.

The basic limitations to the development of overseas television transmission are the magnitude of intercontinental time differences, the relatively large bandwidth requirement of television transmission, and the very cheap and fairly close substitute of airmail videotape. Even if overseas transmission of television were to be available at nominal cost the wide time differentials, together with the network desire to schedule offerings of widest appeal during the prime viewing hours, suggest that most broadcasts in the United States of overseas programs would be delayed transmission from abroad or rebroadcasts from videotape. The relatively large bandwidth requirements of television transmission suggest that the cost of transmission will not be trivial. On transcontinental links in the United States the price of a leased television channel is some twenty-five times the price of a leased voice channel, but the costs of the terminal equipment required for channel division is larger relative to the costs of providing bandwidth on a point-to-point basis for domestic links than for overseas links. As a result, the ratio of the price of an overseas television channel to an overseas voice channel is likely to be much larger if the same basis for pricing is used. It should be noted in this connection that the total revenue of the Long Lines Department of AT&T derived from the transmission of the video portion of commercial television in the United States was only $18 million in 1961. Unless the marginal cost of bandwidth provided by communications satellites turns out to be considerably less than is anticipated by most observers (and unless the price of television transmission is set to reflect marginal costs only) the effective demand for television in 1970 will almost certainly be limited to spot-leasing. Since the criteria to be employed in setting one price of overseas television transmission are unknown, and since they are subject to international agreement they are likely to remain unknown for

some time, the future of overseas television transmission remains highly speculative.

In the very long run the prospects for the development of a market for transmission of program television seem less bright than the prospects for intercontinental transmission of closed-circuit television for purposes other than entertainment. A market for a television conference service analogous to the conference service now offered telephone subscribers will presumably develop at some time in the future, but it is highly unlikely that this will occur by 1970 even for domestic links. The basic limitation on the growth of demand for this type of service is its cost. The cost of providing domestic point-to-point television transmission on an irregular basis has prevented the use of television for conference purposes by American firms, and AT&T does not foresee any cost reductions in the near future that would permit them to offer such a service at terms sufficiently attractive to encourage substantial business use of television for communication. If there is no large domestic market for closed-circuit television in the foreseeable future, there will certainly not be an overseas market for conference television by 1970.

Appendix A

A SELECTED LIST OF REFERENCES TO PREVIOUS RESEARCH ON THE MARKET FOR OVERSEAS TELECOMMUNICATIONS

1. General discussions of the future size of the market for overseas telecommunications are given in the following sources:

Brinkley, J. R., "The Economics of Space Communications," URSI Symposium on Space Communications Research (Paris: September 18-22, 1961) mimeographed;

Meckling, W. H. and Reiger, S., Communications Satellites: An Introductory Survey of Technology and Economic Promise, The RAND Corporation, RM-2709-NASA, September 1960;

Meckling, W. H. and Reiger, S., Economic Aspects of Communication Satellite Systems, The RAND Corporation, P-2396, June 1961.

2. The forecasts of the common carriers are given in the following reports to the Federal Communications Commission:

American Telephone and Telegraph Company, Frequency Needs for Space Communication, Federal Communications Commission Docket No. 11866, June 1960;

———————— , Report of the Ad Hoc Carrier Committee in the Matter of Allocation of Frequency Bands for Space Communications, Federal Communications Commission Docket No. 14024, October 1961.

3. Among the more interesting studies of the future market for overseas telecommunications that have been conducted by private industry are:

Lockheed Aircraft Corporation, Missiles and Space Division, Telecommunication Satellite Business Planning Study, October 1960;

Radio Corporation of America, David Sarnoff Research Center, Study of Overseas Commercial Satellite Communications Systems, 1965-1975, August 1962.

Appendix C

SUBMARINE CABLE CAPACITY IN 1965

Cable Systems	Capacity or Ultimate Capacity (number of 3 kc voice channels)	
U.S.-Europe		344
TAT-1	40	
TAT-2	48	
TAT-3 (scheduled for October 1963)	128	
TAT-4 (scheduled for 1965)	128	
U.S.-Caribbean Points		304
U.S.-Puerto Rico	48	
U.S.-Virgin Islands (scheduled for 1964)	128	
Virgin Islands-Venezuela (scheduled for 1964)	(128)	
U.S.-Jamaica-Canal Zone	128	
U.S.-Pacific Points		176
U.S.-Hawaii-1	48	
U.S.-Hawaii-2 (scheduled for 1964)	128	
Hawaii-Guam-Japan (scheduled for 1964)	(128)	
Guam-Philippines (scheduled for 1964)	(128)	
Canada-United Kingdom		88
TAT-1	8	
CANTAT	80	
Canada-Hawaii-New Zealand-Australia (scheduled for 1963)		80
Malaysia-Hong Kong (scheduled for 1964 or 1965)		80
Australia-Malaysia (completion by 1965 uncertain)		80

Note:

Figures in parentheses are not included in route totals because they refer to channels that do not terminate in the continental United States.

Sources:

R. T. Nichols, Submarine Cables and International Telecommunications, The RAND Corporation, RM-3472-RC, February 1963, and information received from the American Telephone and Telegraph Company.

Appendix B

AD HOC CARRIER COMMITTEE ESTIMATES OF 1970 CAPACITY REQUIREMENTS FOR OVERSEAS TELECOMMUNICATIONS

Route	Capacity Requirement (in voice channels)
U.S.-Europe	1400
U.S.-Africa	70
U.S.-Near East	80
U.S.-West Indies	700[a]
U.S.-Central America and Panama	150
U.S.-South America	450
U.S.-Hawaii	500
U.S.-Asia and Other Pacific Areas	450
Total	3800[b]

Notes:

[a]The Ad Hoc Carrier Committee's estimate of capacity requirements between the United States and the West Indies is 1200 channels, but this includes the requirements of traffic to Cuba and the Bahamas. The estimate of 700 is introduced as an estimate of requirements to Caribbean points other than Cuba and the Bahamas that is consistent with the original estimate of 1200 channels to all Caribbean points.

[b]This total differs from the estimate of 4650 channels given as the committee's forecast of total overseas capacity requirements because of the exclusion of requirements of traffic to Alaska (350 channels) and Cuba and the Bahamas (an estimated 500 channels).

Source:

Report of the Ad Hoc Carrier Committee in the Matter of Allocation of Frequency Bands for Space Communications, Federal Communications Commission Docket No. 14024, October 1961.